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RETURN ORIGINAL? YES ✓ NO

ADDITIONAL INSTRUCTIONS/COMMENTS: Carla - This memo should answer your questions on statistics. We also changed feed limits to 14 and 40. See you Friday.

JJR.

DRAFT MEMORANDUM TASK 1.9(F)

TO: Robert LeVar/AWWU

FROM: Floyd Damron/ANC

DATE: January 23, 1990

RE: Point Woronzof WWTP NPDES/301(h) Renewal
Fecal Coliform Bacteria and Total Chlorine Residual Analysis
Task 1.9(F)

PROJECT: ANC17412.Q5

INTRODUCTION

The Anchorage Water and Wastewater Utility (AWWU) is preparing a permit renewal application for the 5-year period ending 1995 for the Point Woronzof WWTP. The Environmental Protection Agency's (EPA) NPDES/301(h) permit renewal process has requirements for the state. The state is required to provide a letter confirming that AWWU's proposed modified discharge will comply with applicable provisions of state law, including applicable water quality standards. AWWU is requesting the Alaska Department of Environmental Conservation (ADEC) to provide Alaska's letter to EPA.

ADEC has requested that AWWU analyze effluent fecal coliform bacteria counts and chlorine residual concentrations for historical data from the Point Woronzof treatment plant. This will assist their evaluation of the proposed modified discharge. AWWU is proposing to modify the existing diffuser by adding three 18-inch reducing nozzles to the existing 23-inch ports. The requested analyses are to determine how well the treatment plant has been meeting the existing discharge permit requirements and to calculate how well it can meet new permit requirements. The results of the analyses will be used by ADEC to establish the new NPDES permit discharge and mixing zone requirements for fecal coliform bacteria and residual chlorine.

This draft memorandum for Task 1.9(F) presents the results of the analyses requested by ADEC. Our permit renewal recommendations are contained in the last section of this memorandum.

STATE OF ALASKA REQUIREMENTS

The existing NPDES/301(h) permit has the following requirements:

"I.A.4. Page 4 of 41, Permit No. AK-002255-1

4. The Alaska Department of Environmental Conservation (ADEC) has designated the following mixing zones:

a. **Fecal coliform bacteria.** A circle with a radius of 245 m centered on the diffuser. Outside this zone, the fecal coliform limit of 14 FC/100 ml (based on a minimum of five samples taken in a period of 30 days) shall be met.

b. **Residual chlorine.** . . . this zone is approximately three-fourths of a circle, centered on the outfall, with a radius of 600 m . . .

5. The following effluent limitations shall apply:

Effluent Characteristics	Unit of Measurement	Monthly Average	Weekly Average	Daily Maximum
Fecal Coliform Bacteria	FC MPN/100 ml	850[a]		
Total Residual Chlorine	mg/l	1.2	--	1.4

[a]Geometric mean of at least five samples. Not more than 10% of the samples shall exceed 2,600 FC MPN/100 ml."

The ADEC requirement for total residual chlorine concentration to be met at the edge of the 600 meter mixing zone is 0.002 mg/l, or 2 ug/l. This concentration is based on Alaska's receiving water quality criteria. The monthly average fecal coliform limit of 850 FC MPN/100 ml is based on a mixing zone dilution ratio of approximately 60:1 and a limit of 14 FC/100 ml (60.7 X 14 FC/100 ml = 850 FC/100 ml). The permit requirement that ten percent of the samples not exceed 2,600 FC MPN is based on a dilution ratio of approximately 60:1 and a limit of 40 FC/100 ml at the edge of the state mixing zone (65 X 40 FC/100 ml = 2,600 FC/100 ml).

ANALYSIS OF EXISTING DATA

The reported fecal coliform, chlorine residual, and flow data for the existing permit period, October 1985 to May 1989, were analyzed to develop relationships to allow prediction of future allowable fecal coliform and chlorine residual concentrations in the effluent at the diffuser. Figures 1 and 2 show the results of this analyses.

According to the Handbook of Chlorination, 2nd Edition, effluent coliform concentrations are an inverse function of RT, the product of chlorine residual (R) and detention time (T). The Point Woronzof treatment plant chlorine residual (R) is determined from a grab sample that is pumped to the treatment plant from a point near the beginning of the outfall pipeline. The detention time (T) is based on effluent flow rate and size of the channels, tunnels, and pipelines downstream of the chlorine injection point.

This inverse function of RT was evaluated for 561 reported final effluent chlorine residual and fecal coliform counts and for a geometric mean of the reported monthly fecal coliform counts. Ten or more fecal coliform samples were taken at Point Woronzof each month.

Figure 1 shows the plot of the monthly geometric mean fecal coliform count versus RT value. The

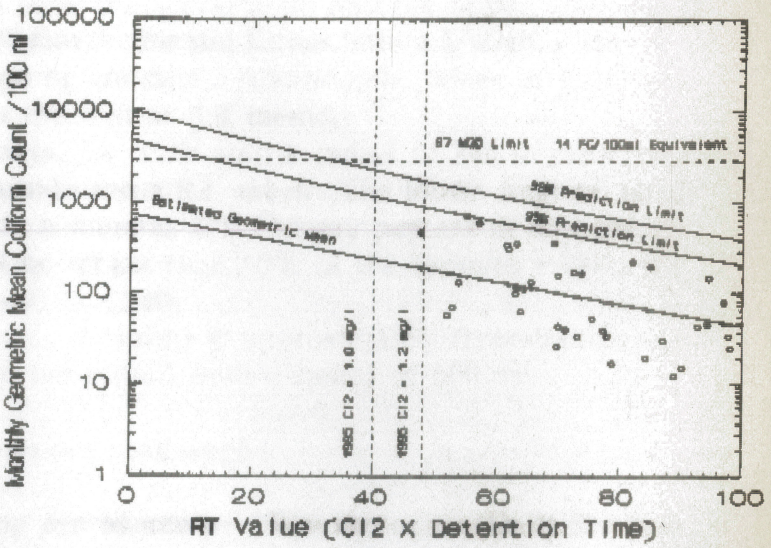

Fig. 1 Estimated geometric mean fecal coliform based on RT value.

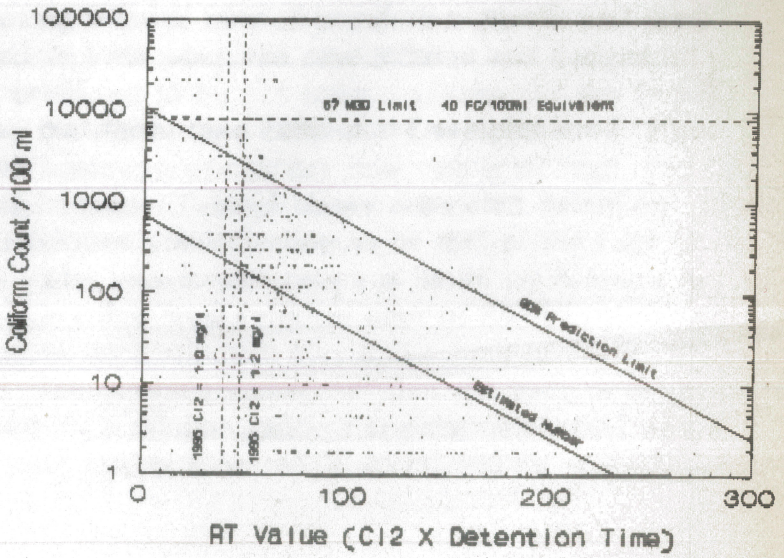

Fig. 2. Estimated fecal coliform count based on RT value.

lowest solid line is the geometric mean of coliform count based on the regression relation with the RT value. The middle solid line is the 95% prediction limit, and the upper solid line is the 99% prediction limit. (Note that, for Figure 1, the prediction lines are slightly curved because the lines extend well beyond the range of the data. Additionally, tables of statistical values for Figures 1 and 2 are presented at the end of this memo.)

Figure 2 shows the plot of fecal coliform count versus RT value. The lower diagonal solid line is the best fit regression relationship of coliform to RT. Ninety percent of all coliform values fall below the upper diagonal solid line. (Less than 10% of the samples exceed the 245 meter dilution times 40 FC/100ml [206x40 = 8,240].)

FUTURE CONDITIONS

Detention Time

Detention time (T) is calculated by modeling the wastewater flow through each of the hydraulic structures downstream of the location where chlorine is added. A liquid chlorine solution is added immediately upstream of the Point Woronzof Parshall flume approach channel. Since the hydraulic structures downstream of the chlorination point are existing, and no new structures are proposed, the flow rate is the only variable in the detention time calculation.

The Municipality of Anchorage is experiencing a lower rate of population growth and resultant wastewater flows than were anticipated in 1984 when the new diffuser was designed. (The year 2005 peak day design flow was predicted to be 128 million gallons per day [mgd].) Based on current population projections by the Anchorage Economic Development & Planning Department, the anticipated year 1995 wastewater peak day flow rate is 67 mgd, and the year 2005 wastewater peak day flow rate is 76 mgd. Table 1 shows calculated detention times for 1995 and 2005 flows rates.

Table 1
DETENTION TIME

Flow, mgd	Type of Flow	Year	Detention Time (T), min
30	Average Day	1995	88
67	Peak Day	1995	40
35	Average Day	2005	76
76	Peak Day	2005	35
128	1984 Estimated Peak Day	2005	21

Dilution

The dilution ratios for the 1990-1995 permit period will be much higher than the 60:1 dilution ratio used in the 1985-1990 permit period for several important reasons:

- Reduced Flows--The Point Woronzof treatment plant is experiencing slower growth in effluent flows due to the decreased rate of Anchorage population growth.
- Modified Diffuser--The proposed addition of 18-inch reducing nozzles to the three 23-inch diffuser ports will increase the effluent discharge velocity.
- Dye Study--The 1988 dye study results provide greater dilution analysis reliability.

As a result of the reduced wastewater flows compared to the flows predicted during the treatment plant expansion design (see Table 1) AWWU is planning to install three 18-inch reducing nozzles on the trifurcated diffuser. The nozzles are proposed to be installed during the 1991 construction season. These nozzles will increase the diffuser port exit velocity and effluent dilution in upper Cook Inlet.

In July 1988, a dye study was conducted in upper Cook Inlet at the Point Woronzof trifurcated diffuser. The results of this study were compared to various mathematical dilution models. The EPA model UDKHDEN, adjusted for the effect of the surface and sea floor, most closely modeled the results of the dye study and was selected to predict dilutions at future flows. This is discussed further in four memorandums, Task 1.9 (A), (B), (C), and (D), from CH2M HILL to AWWU.

Dilutions of various effluent flows and distances were predicted using the adjusted EPA initial dilution model UDKHDEN. Input to this model included the characteristics of the modified diffuser and data from the 1988 dye study. The analyses are presented in the Task 1.9 (E) memorandum, dated May 5, 1989, from CH2M HILL to AWWU. The dilution analyses have been reviewed and have received tentative approval by EPA Region X.

The dilution model UDKHDEN was used to predicted effluent dilutions at the existing ADEC designated permit mixing zones of 245 and 600 meters. The relationship between dilution and flow for these two mixing zones is shown on Figures 3 and 4.

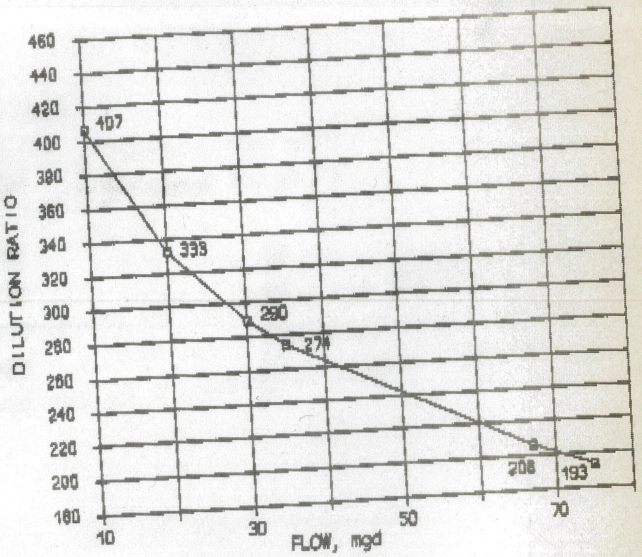

Fig. 3. Dilution ratio 245 meters from outfall.

Total Chlorine Residual

The future allowable effluent chlorine residual was calculated using the predicted UDKHDEN 600 meter dilution (see Figure 4) at the projected year 1995 peak day flow rate of 67 mgd, times the receiving water standard of 2 ug/l (0.002 mg/l). This calculation results in a future allowable effluent chlorine residual of 0.9 mg/l (0.002 mg/l times 452). ADEC has agreed to consider a mixing zone with a larger radius so the peak day chlorine residual can remain at 1.2 mg/l, the existing permit limit. ADEC has also requested that calculations be made for a chlorine residual of 1.0 mg/l so a comparison can be made.

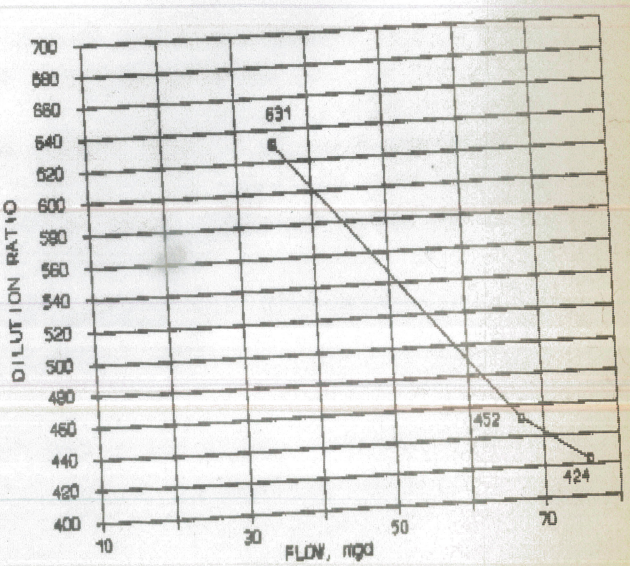

Fig. 4. Dilution ratio 600 meters from outfall.

COMPLIANCE WITH PERMIT REQUIREMENTS

Fecal Coliform Bacteria

Based on the predicted future effluent characteristics and dilution, the anticipated RT values at 67 mgd are 40 and 48 minutes mg/l (1.0 and 1.2 mg/l, R, times 40 minutes, T). These RT values are shown as vertical dashed lines on Figures 1 and 2.

The allowable fecal coliform concentrations in the effluent are based on the predicted dilutions at the 245 meter state mixing zone boundary for a flow rate of 67 mgd times the permit standard of 14 and 40 FC MPN/100 ml. Each is shown as a horizontal dashed line on Figures 1 and 2.

The test we used to determine if future plant discharges will meet permit requirements was a two part test:

- To meet the 14 FC MPN/100 ml permit requirement at the edge of the state's 245 meter mixing zone, the monthly geometric mean at the predicted RT value cannot exceed 2,900 FC MPN/100 ml (14 FC times 206 dilution ratio). Figure 1 shows that this requirement will not be exceeded for the year 1995 peak day flow rate of 67 mgd.

- To meet the 40 FC MPN/100 ml permit requirement at the edge of the state's 245 meter mixing zone, no more than 10% of the fecal coliform samples can exceed 8,200 FC MPN/100 ml (40 FC times 206 dilution ratio). Figure 2 shows that the 90% prediction is below 8,200 FC MPN/100 ml at the predicted 1995 RT values. Therefore, this requirement will not be exceeded for year 1995 peak day flow rate.

Both parts of the 2-part test can be met when the predicted year 1995 peak day flow rate of 67 mgd is discharged from the Point Woronzof treatment plant.

Total Residual Chlorine

The control of residual chlorine (R) in the effluent from a primary treatment plant is very sensitive to variations in the effluent quality and flow rate. This is especially true at low effluent residuals. Based on the experience of the operators at the Point Woronzof treatment plant, they need an effluent chlorine residual range of about 0.3 mg/l to maintain permit limits. Additionally, the analyses represented on Figures 1 and 2 are based on data from lower flow rates than are projected for the permit renewal period. There is some risk that the RT

versus fecal coliform count relationship will be somewhat different at higher treatment plant flow rates. (Some treatment processes may not be as efficient at higher flows.) Therefore, the new permit should maintain the existing total chlorine residual limits of a monthly average of 1.2 mg/l.

Based on the estimated future effluent flow rate, the predicted daily average dilution, and the total chlorine residual requirement at the edge of the mixing zone, total effluent residual at the diffuser can be estimated for various flow rates and mixing zones. The results of these computations are presented on Figures 5 and 6. Figure 6 shows that, for the year 1995 peak daily flow rate of 67 mgd, a mixing zone radius of 820 meters is required. At 820 meters, the total chlorine residual in the effluent is diluted from 1.2 mg/l to 0.002 mg/l (2 ug/l). If ADEC reduces the allowable effluent chlorine residual to 1.0 mg/l, Figure 6 shows that a mixing zone with a radius of 680 meters will be required.

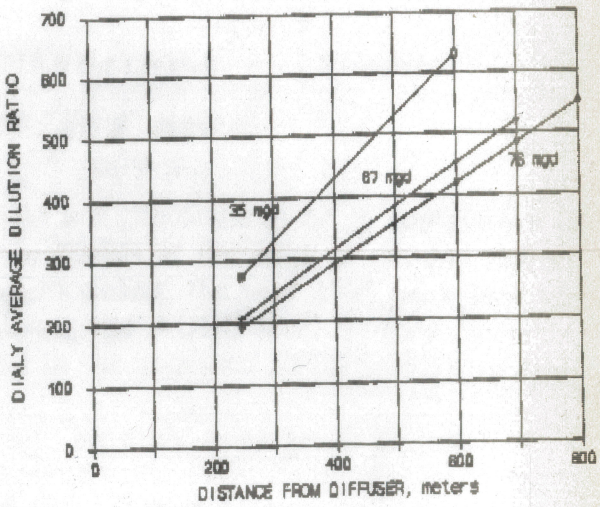

Fig. 5. Distance - Dilution ratio for various outfall flows.

Shape of the Mixing Zone

The shape of the mixing zone is determined by the tidal currents in upper Cook Inlet. These currents are strong and, as the tide changes, reverse in less than one hour. The effluent plume is long and narrow, with some widening when the current changes direction. Hourly plots of the plume shape over a 24-hour period are presented in our Memorandum, Task 1.9(E), to AWWU.

Figure 7 shows the size and shape of the proposed new mixing zone for the 1990-1995 permit period.

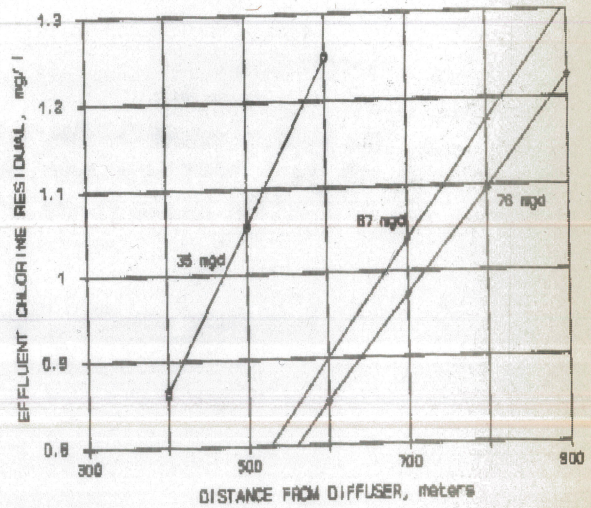

Fig. 6. Distance from outfall to meet 2 ug/l chlorine limit for various flows and effluent chlorine residuals.

NEW NPDES PERMIT REQUIREMENT RECOMMENDATIONS

Fecal Coliform Bacteria

The Point Woronzof WWTP discharges have been and are predicted to be in compliance with ADEC permit requirements for fecal coliform bacteria counts at the edge of the 245 meter mixing zone. Based on dye study results and dilution modeling, the year 1995 peak flow of 67 mgd will have a 245 meter dilution ratio of 206:1. Using the ADEC fecal coliform bacteria permit requirements, the following should be included in the renewed NPDES/301(h) permit:

Effluent Characteristic	Unit of Measurement	Monthly Average
Fecal Coliform Bacteria	FC MPN/100 ml	2,900[a]

[a]Geometric mean of at least 5 sample. Not more than 10% of the samples shall exceed 8,200 FC MPN/100 ml.

(14 FC times 206 = 2,884 FC; 40 FC times 206 = 8,240 FC)

Total Residual Chlorine

The total residual chlorine should be at or less than the ADEC water quality standard of 2 ug/l at the edge of the 820 meter radius mixing zone for the year 1995 peak day flow rate of 67 mgd. This can be met for the improved discharge if the renewed NPDES/301(h) permit has the following total residual chlorine requirements:

Effluent Characteristic	Monthly Average	Daily Maximum
Total Residual Chlorine[a]	1.2 mg/l	1.4 mg/l

[a]The mixing zone is described on Figure 7.

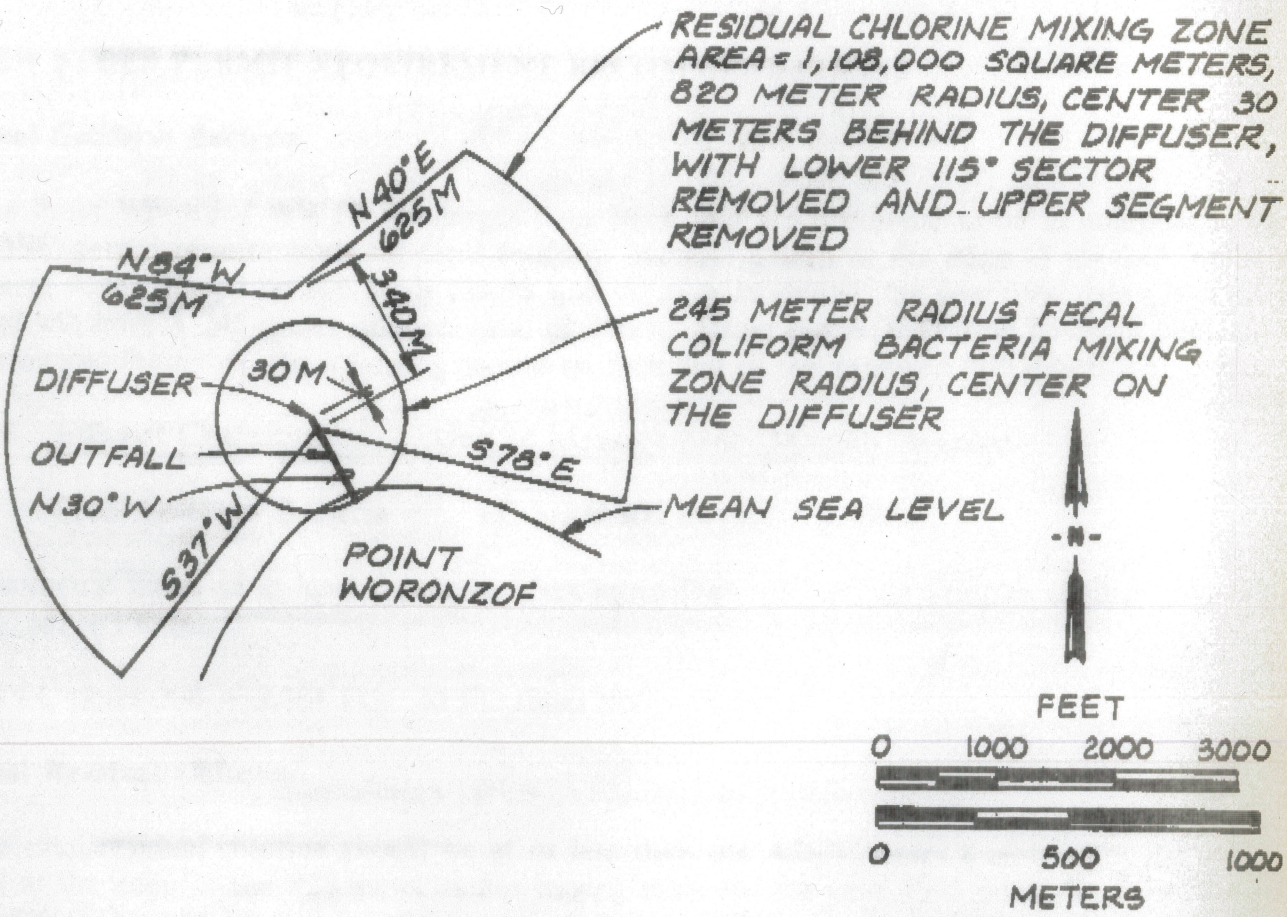

Fig. 7. Proposed mixing zones for fecal coliform bacteria and total residual chlorine.

Table 1
REGRESSION STATISTICS FOR FIGURE 1

Model LNCOLI = Constant + b1*RT
LNCOLI is mean monthly log of coliform count

DEP VAR: LNCOLI N: 44 MULTIPLE R: .487 SQUARED MULTIPLE R: .237
ADJUSTED SQUARED MULTIPLE R: .219 STANDARD ERROR OF ESTIMATE: 0.917

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	6.595	0.628	0.000	.	10.498	0.000
RT	-0.028	0.008	-0.487	1.000	-3.610	0.001

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	10.947	1	10.947	13.029	0.001
RESIDUAL	35.287	42	0.840		

Table 2
REGRESSION STATISTICS FOR FIGURE 2

Model LNCOLI = Constant + b1*RT
LNCOLI is log of coliform count

DEP VAR: LNCOLI N: 561 MULTIPLE R: .477 SQUARED MULTIPLE R: .228
ADJUSTED SQUARED MULTIPLE R: .226 STANDARD ERROR OF ESTIMATE: 2.094

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	6.562	0.191	0.000	.	34.367	0.000
RT	-0.028	0.002	-0.477	1.000	-12.837	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	722.289	1	722.289	164.794	0.000
RESIDUAL	2450.095	559	4.383		